14th International Research/Expert Conference
”Trends in the Development of Machinery and Associated Technology”
TMT 2010, Mediterranean Cruise, 11-18 September 2010

SIMULATION RESEARCH OF HEAVY PLANER MILLS

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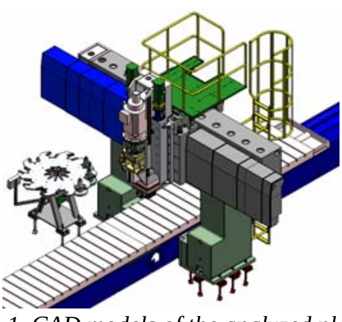
ABSTRACT
The paper presents results of finite element analyses of heavy milling machines. The analyses included two machine tools and were conducted on the design level. The results of initial dimensional optimization of the supporting structure of the milling machine led to the improvement of its structural design as well as to the improvement of the following machines' designs. Influence of modifications of column's overall dimensions on natural frequencies of the supporting structure is shown too. Moreover the paper presents also results of static stiffness analysis and modal analysis obtained by the use of Ansys system.
Keywords: analysis and modeling, machine tools, optimization

1. INTRODUCTION

Heavy Machine tools have been focal devices for the scientific research conducted at the Machine Technology Department of Silesian University of Technology in Gliwice. It results from close cooperation of the faculty members with the industrial sector and machine tool manufacturers such as: Rafamet S.A., or Design Technologies International. The companies are market leaders of Polish machine tool industry and on top of that they are also widely renowned internationally as prestigious heavy machine tool producers. The scientific research includes both experimental examination on newly designed machines as well as their model examination taking the advantage of finite elements method. The research conducted so far focused mainly on measuring static stiffness, dynamic stiffness, identifying dynamic properties of machine tools and thermal analyses. Recently, the scope of the research has been broadened so as to include analyses aiming at optimization of a machine tool body [1][2][3][4][5]. The present paper has been based on results obtained in the course of analyses of two new designs of heavy planner mills (Figure 1).

a)



b)

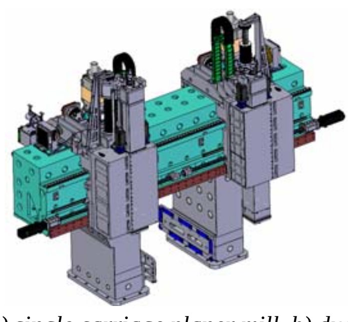
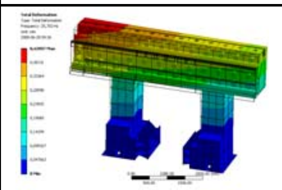
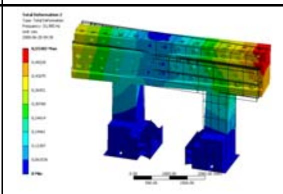
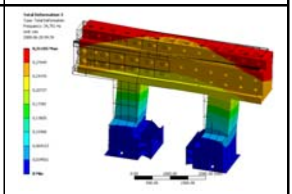
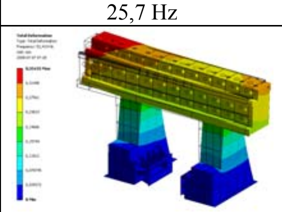
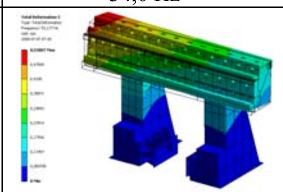
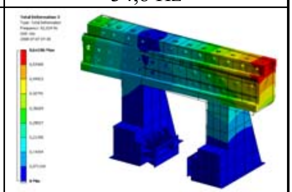


Figure 1. CAD models of the analyzed planer mills: a) single carriage planer mill, b) dual carriage planer mill

2. MODEL RESEARCH

Two heavy planer mills were chosen as the research subject. Firstly, single carriage planer mill underwent the analysis. The calculations that were done by the use of Ansys system concerned the analysis of static stiffness, mode shapes and natural frequencies. The figures obtained due to the analyses revealed low stiffness of the columns thus making the manufacturer and authors of the present paper verify the impact of different columns' dimensions onto the results obtained. Optimization process of machine tool bodies involved classical approach relaying on implementation of expert-designer know-how together with analyses based on finite elements method. The results obtained are presented in Table 1 and Figure 2. Eventually, having taken into consideration technological factors, it was possible to choose the solution, which entailed strengthening of the initial structure with steel holders and filling up the columns with concrete. It enabled the increase of the first natural frequency of the supporting structure approximately by 104 %, as compared to the frequency obtained for the initial form of the columns. The value of first natural frequencies for various column dimensions is shown in Figure 2.

Table 1. Listing of results for the eventually accepted form of the columns strengthened with steel holders and filled with concrete

	natural frequency		
	1	2	3
genuine structure	 25,7 Hz	 34,0 Hz	 34,8 Hz
structure with steel holders	 52,4 Hz	 53,2 Hz	 62,0 Hz

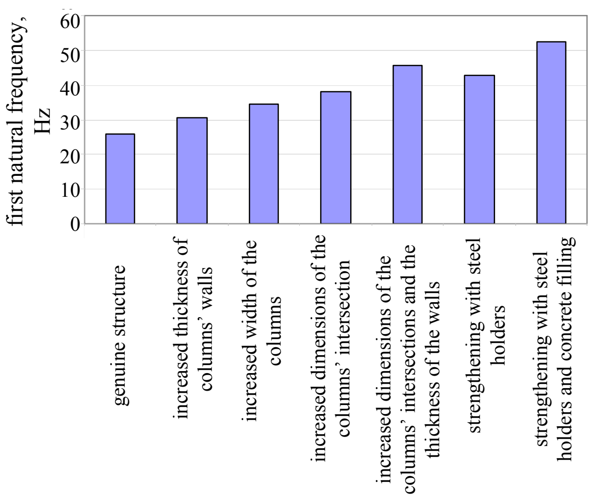


Figure 2. Listing of the first natural frequencies for various design variants of columns in case of single carriage planer mill

The analysis of results obtained due to the examination of single carriage planer mill proves that the highest stiffness of the milling unit is towards X direction and appears when the carriage is placed centrally and the slide is in position. Slide's advancement to its extreme causes decrease of static stiffness by more than 50%. Similarly, slide's advancement with the extreme location of the carriage entails stiffness decrease by approximately 50%. This proves previous conclusions on relatively high importance of columns' susceptibility in overall susceptibility of the whole milling unit. In case of Y direction however, the location of the carriage does not influence static stiffness to such a great extend. Stiffness for the extreme and middle positions is fairly similar. The role of slide's advancement is also decreasing, although its influence is still significant.
The design of dual carriage planer mill was completed later in time. The construction of the supporting structure contains certain improvements, which are direct consequences of the optimization process whose results are presented above. The analyses revealed significant increase of stiffness towards table's advancement (X direction) and towards carriage's advancement (Y direction), with the slide in position. Whereas, the comparison of static stiffness results for the slide in the advanced position reveals that the design change of the supporting structure improved the out-put figures insignificantly. It seems that, more susceptible design of the slide itself influences the results to a greater extend.
Additionally, it has been discovered that the results obtained in the course of modal analysis of the dual carriage planer mill are fairly comparable to those of single carriage planer mill, despite the fact that planer mill' stiffness in X and Y directions is almost doubled. The values obtained result from mounting two carriages which in turn doubles the weight.
Furthermore, results of FEM analysis conducted on both planer mills leads to conclusion that static stiffness measured for the same carriage positions, while changing the slide location only, from in position to advanced one, can decrease even three times. Positioning of the carriage and slide does not influence significantly the natural frequencies (Figure 3c and 4d).

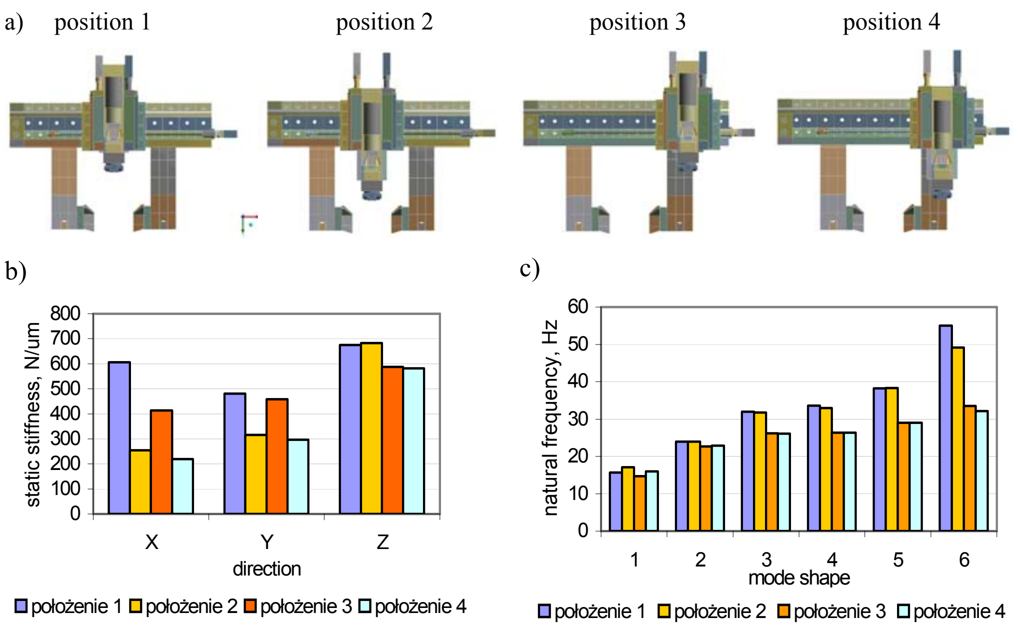


Figure 3. Listing of stiffness results of the milling unit: a) selected positions of the carriage and the slide, b) static stiffness analysis results, c) modal analysis results

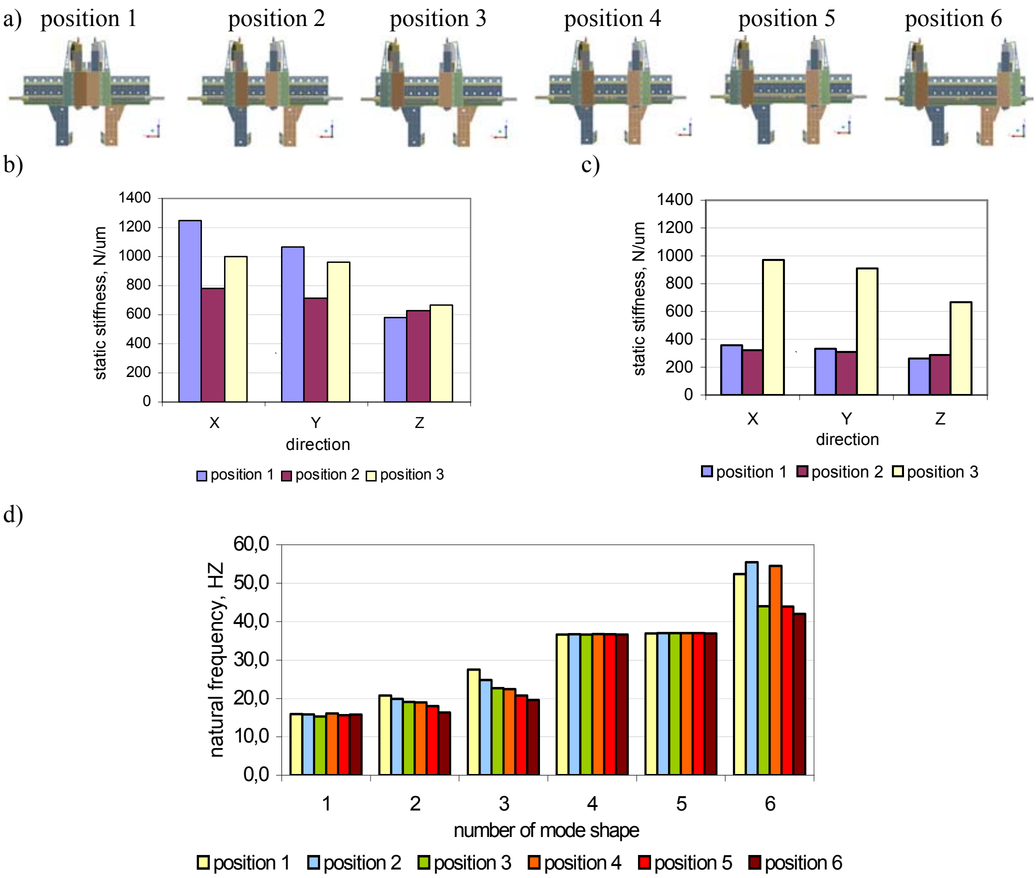


Figure 4. Listing of dual carriage planer mill results: a) selected positions of the carriage and the slide, b) static stiffness analysis results for the slide in position, c) static stiffness analysis results for the advanced slide, d) listing of natural frequencies for the advanced slide

3. CONCLUSIONS

The above presentation of results proves that model research conducted during the designing stage of heavy machine tools leads to their improved accuracy and exploitative properties. Optimization appears to be vital for designing a structure with strong competitive edge. The results obtained for one machine tool however, should not be generalized and transferred onto the whole range of machine tools, since geometrical form of the body and its loading resulting from e.g. weight of movable bodies are equally important.

4. REFERENCES

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